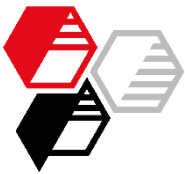




Urea-resistant EPDM gaskets and hoses: Replacement of carbon black N990 with Aktisil VM 56 VW TL 52686

Author: Michael Aufmuth



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- Objective

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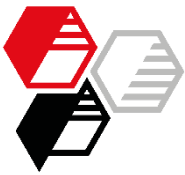
- Formulation and fillers
- Preparation and curing of the compound
- Requirements

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- Rheology
- Mechanical properties
- Storage in hot air
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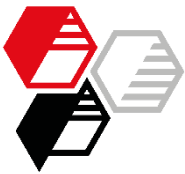
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VW TL 52686

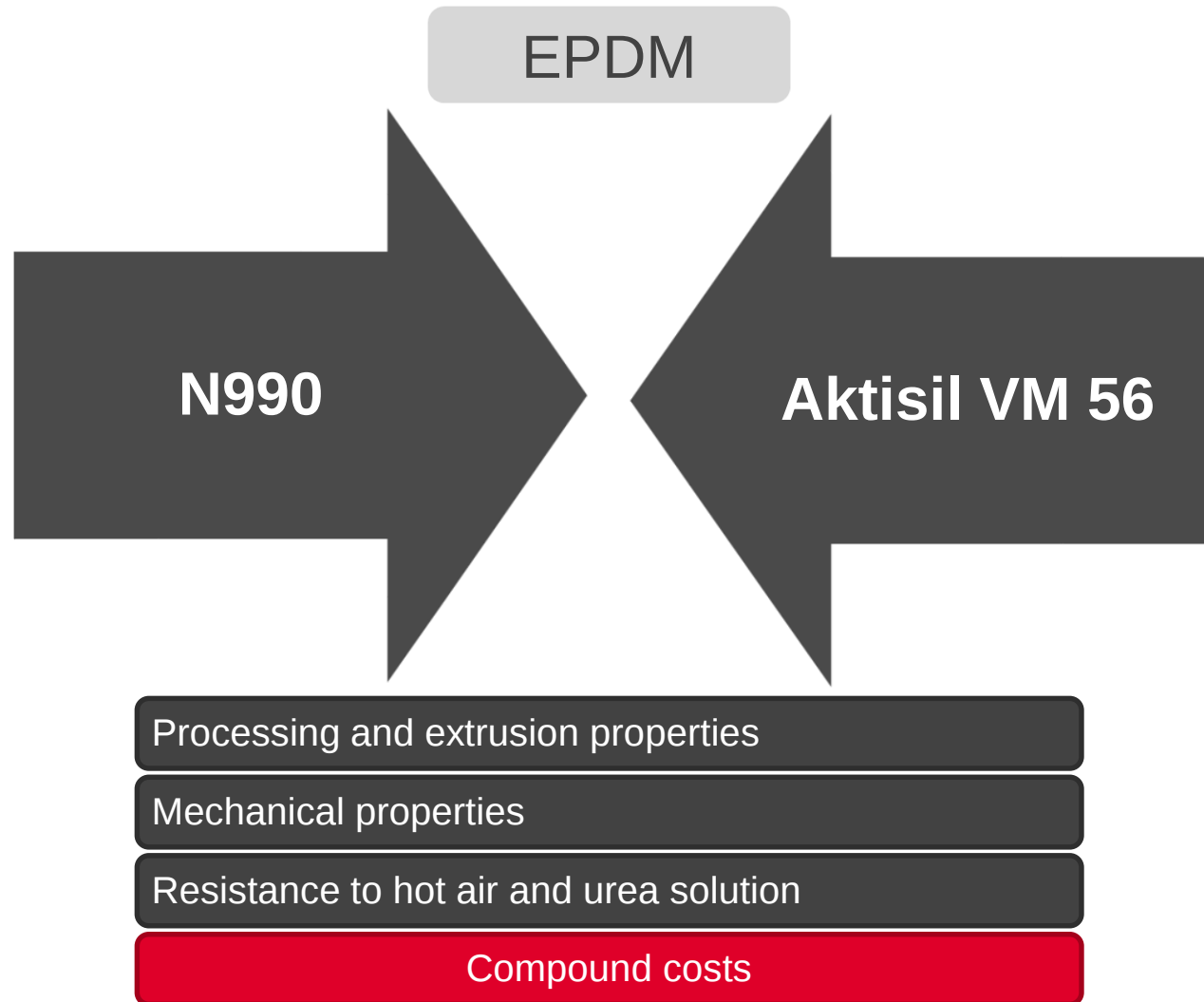
Elastomer Materials Resistant to AdBlue Used for Exhaust Gas Treatment (SCR)

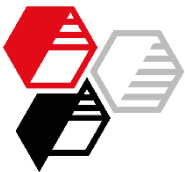
- Use of elastomers for gaskets, such as O-rings (TL 52686-A) and molded hoses (TL 52686-B)
- Possible use of different polymers: EPDM, HNBR, TPE-V
- Typically used filler: Carbon Black N990



Objective

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Formulation

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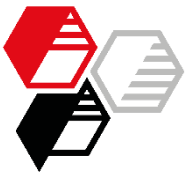
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Material	Description	phr	phr
Keltan 4450S	Ethylene Propylene Diene Rubber, amorphous, ML 1+4 (125 °C): 42 MU	100	100
Carbon Black N990	Carbon Black MT	120	
Aktisil VM 56	NSE, surface treated		120
Process Oil P460	Paraffinic plasticizer	20	20
Vulkanox HS/LG	Antioxidant, TMQ	1	1
TAC GR 70	Triallylcyanurate, 70%, coagent	1	1
Perkadox 14-40B-pd-s	Di(tert-butylperoxyisopropyl) benzene peroxide	5	5
Total		247	247



Fillers, Characteristics

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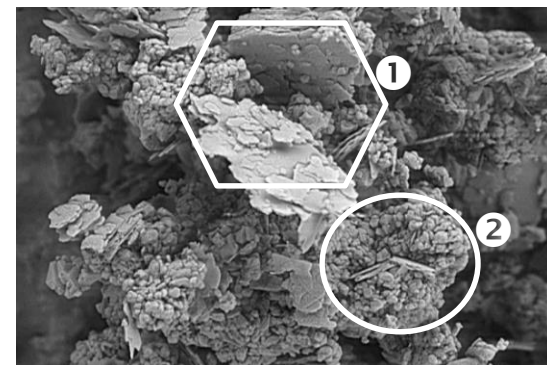
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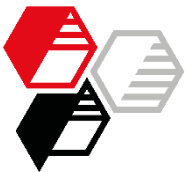
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		CB N990	Aktisil VM 56
Density	[g/cm ³]	1.8	2.6
Particle size d ₅₀	[μm]		2.2
Particle size d ₉₇	[μm]		10
Sieve residue > 40 μm	[mg/kg]		20
Sieve residue 45 μm/325 mesh	ppm	18	
Oil absorption	[g/100g]		45
DBP absorption	[ml/100 g]	38	
Specific surface area BET	[m ² /g]		9
CTAB surface area	[m ² /g]	7	
Functionalization		none	Vinyl



① lamellar: kaolinite

② corpuscular: silica



Preparation and Curing of the Compound

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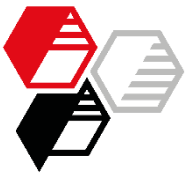
APPENDIX

Mixing

Open mill	Ø 150 x 300 mm
Batch amount	approx. 750 g
Temperature	50 °C
Mixing time	Approx. 15 min.

Curing

Press temperature	180 °C
Curing time	$t_{90} + 10 \%$



Requirements acc. to VW TL 52686

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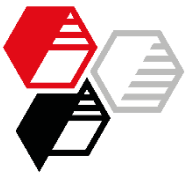
Version A (O-ring) and version B (hose inner core) 1/2

Mechanical properties

Hardness	Shore A	65 ± 5
Tensile strength	MPa	≥ 8
Modulus 100 %	MPa	≥ 2.5
Elongation at break	%	≥ 200
Compression set 94 h / 23 °C	%	< 20
Compression set 22 h / 120 °C	%	< 65

Storage in hot air

120 °C		94 h	504 h
Δ Hardness	Shore A	0 to +5	0 to +10
Tensile strength	MPa	≥ 8	≥ 8
Elongation at break	%	≥ 150	≥ 130



Requirements acc. to VW TL 52686

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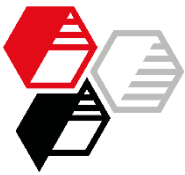
Version A (O-ring) and version B (hose inner core) 2/2

Storage in urea solution , 32 %, ISO 22241

80 °C		94 h	504 h
Δ Hardness	Shore A	± 5	± 5
Tensile strength	MPa	≥ 8	≥ 8
Elongation at break	%	≥ 200	≥ 200
Δ Weight	%	0 to +3	0 to +5

- **Tests**

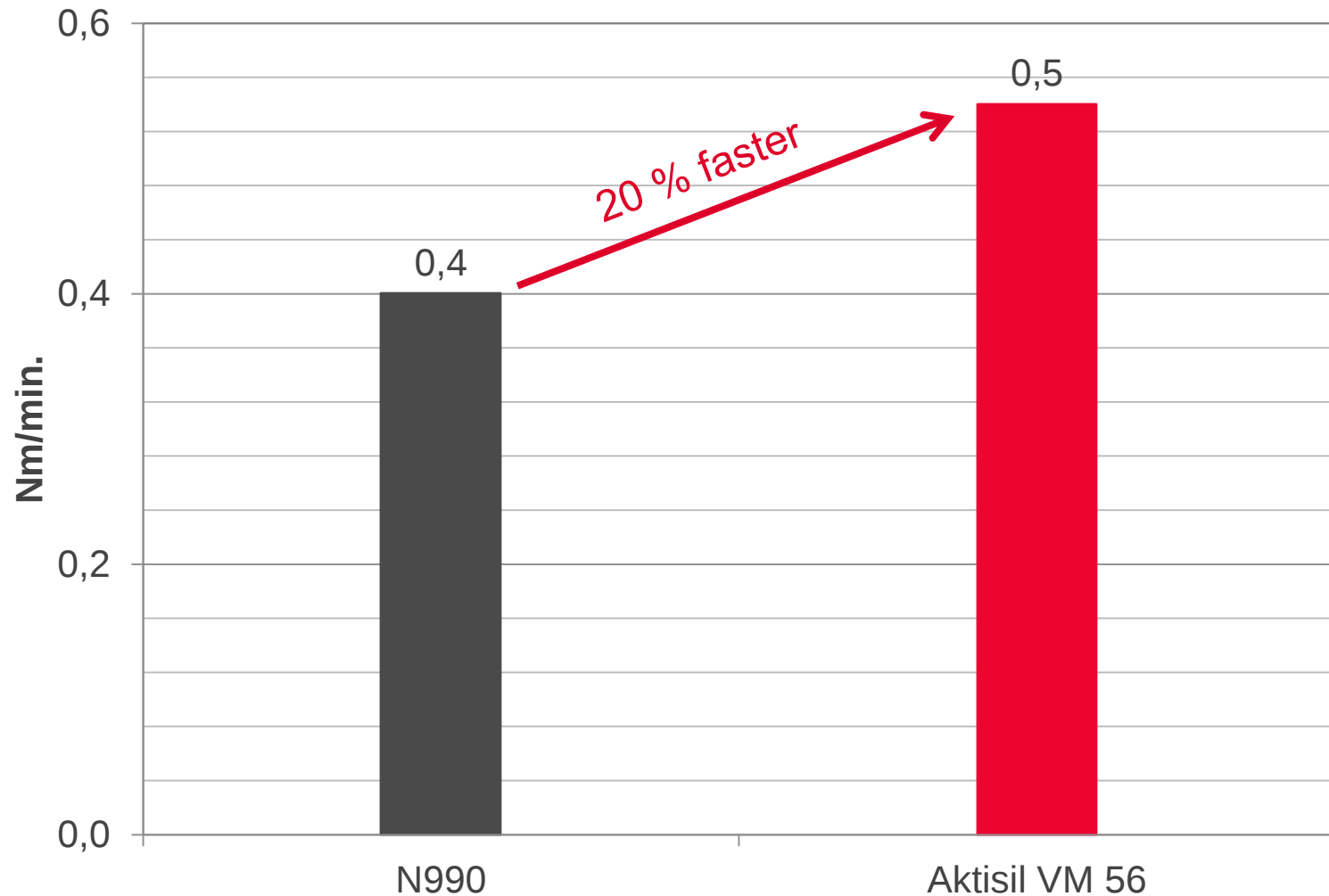
Based on DIN with test parameters VW standards TL 52686

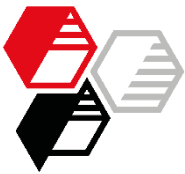


Maximum Cure Rate, 180 °C

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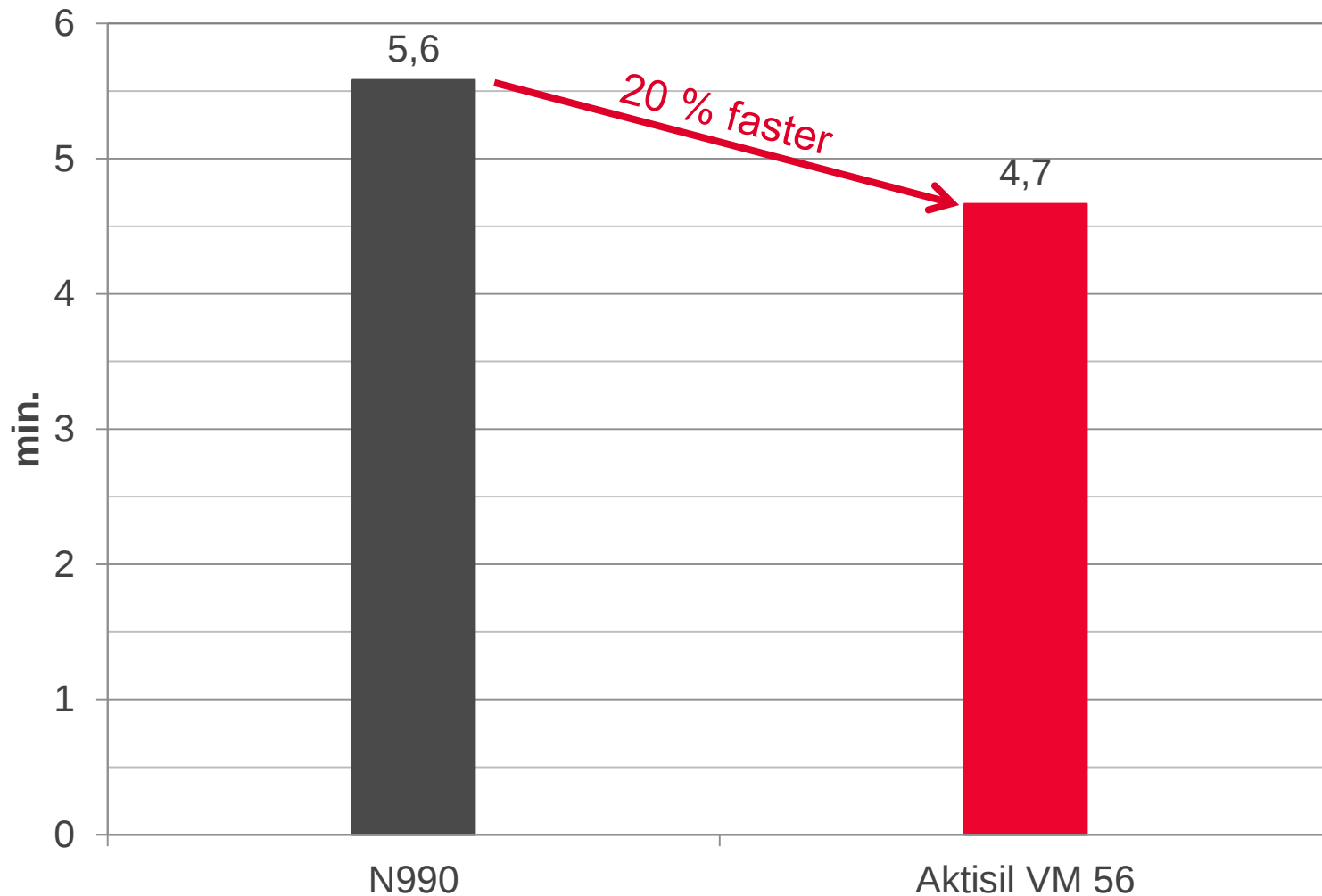
DIN 53 529-A3, 0.2° deflection – Göttfert Elastograph

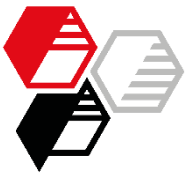




Conversion Time t_{90} , 180 °C

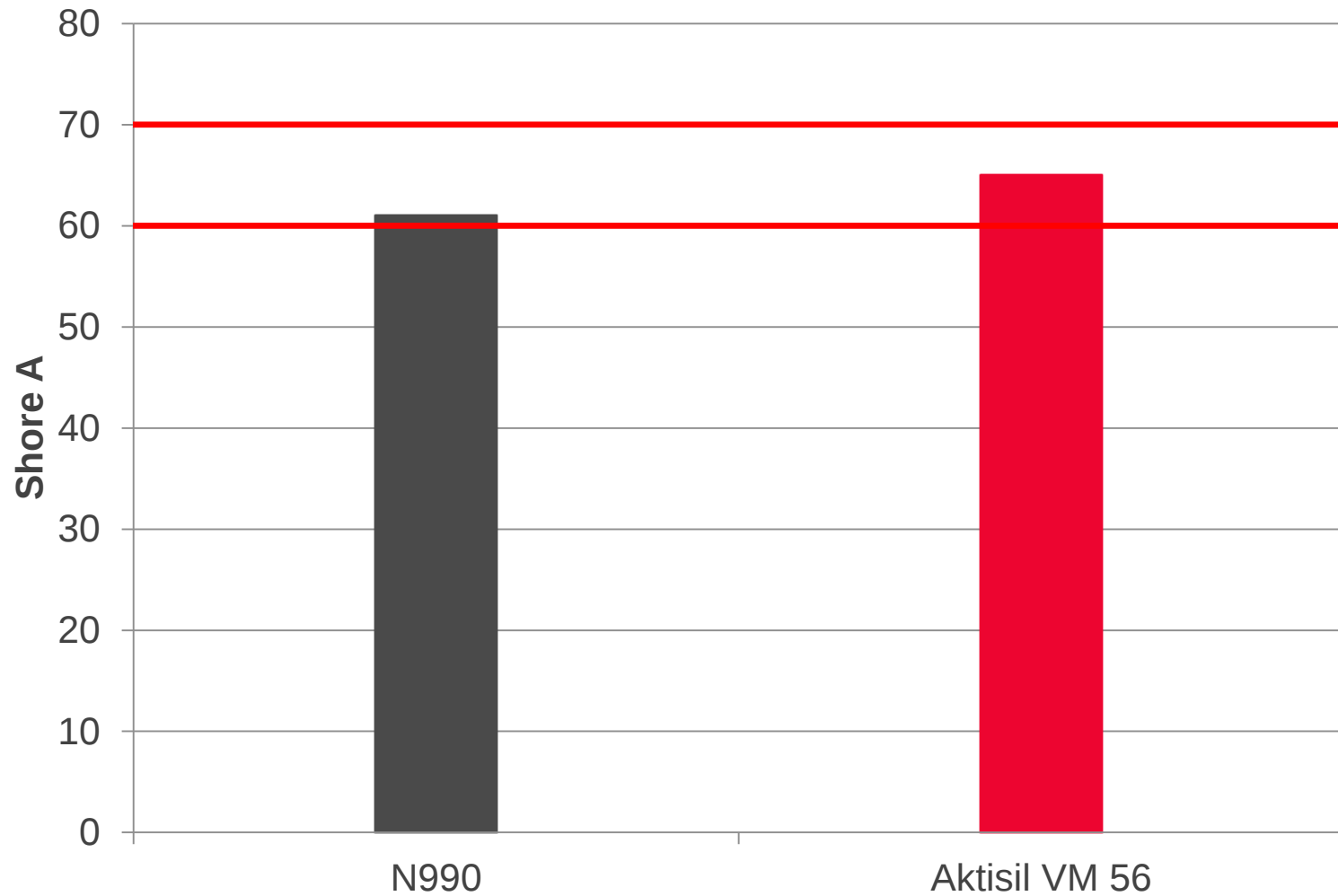
DIN 53 529-A3, 0.2° deflection – Göttfert Elastograph

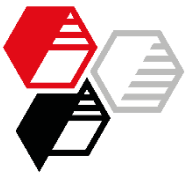




Hardness

DIN ISO 7619-1, piled-up S2 dumbbells

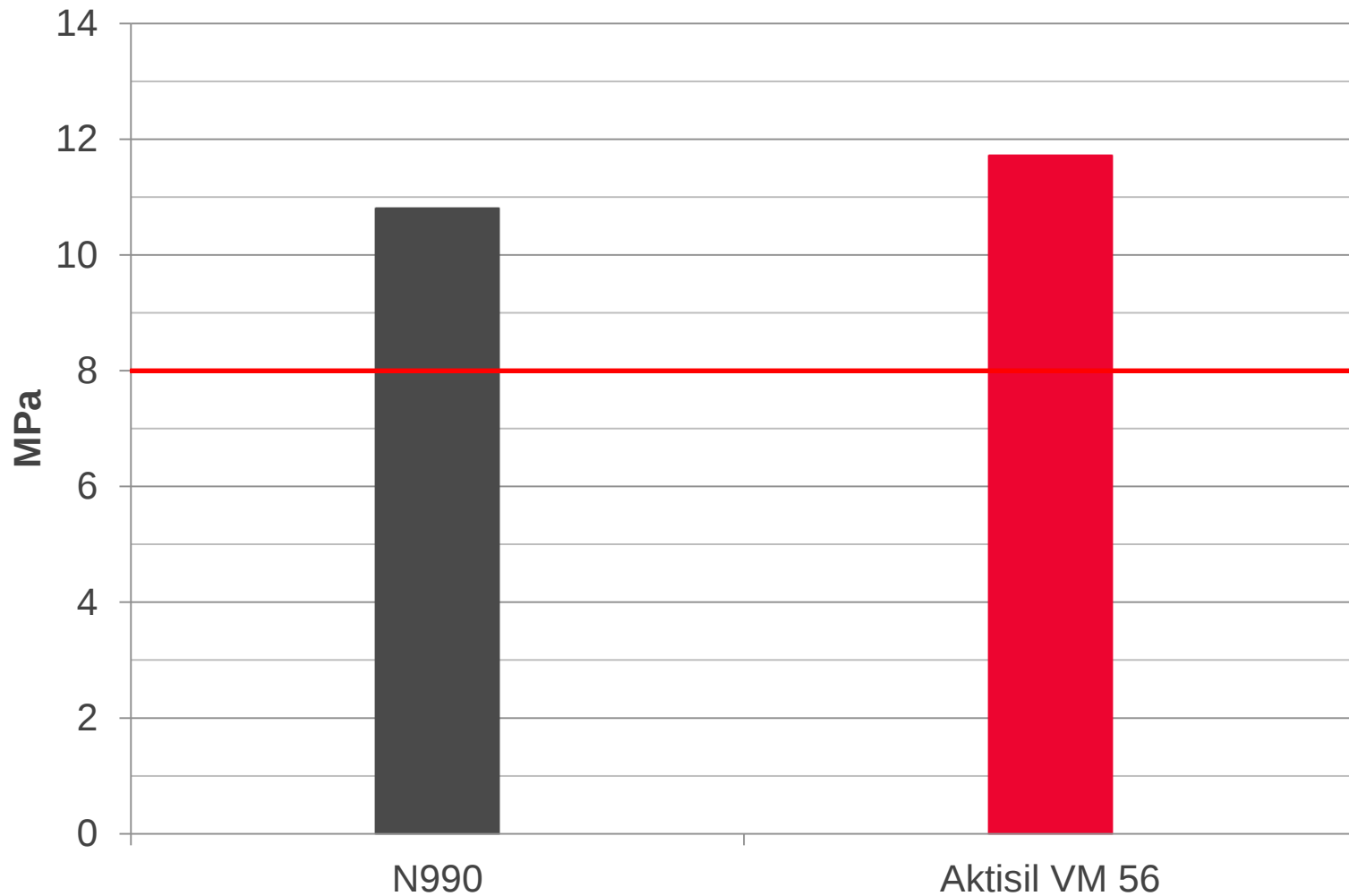


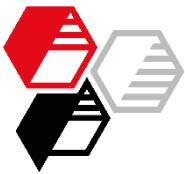


Tensile Strength

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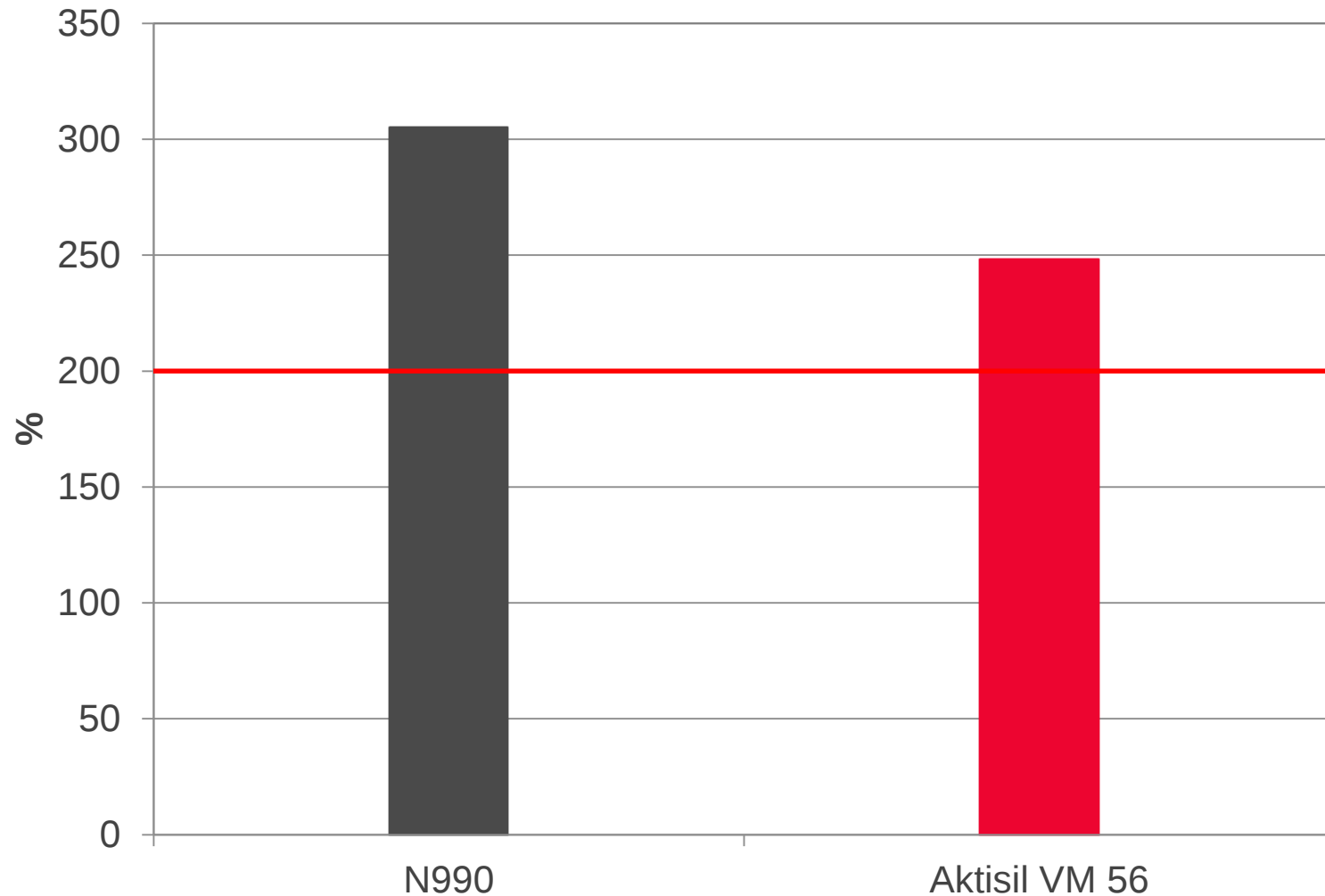
DIN 53 504, S2

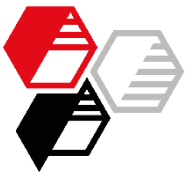




Elongation at Break

DIN 53 504, S2

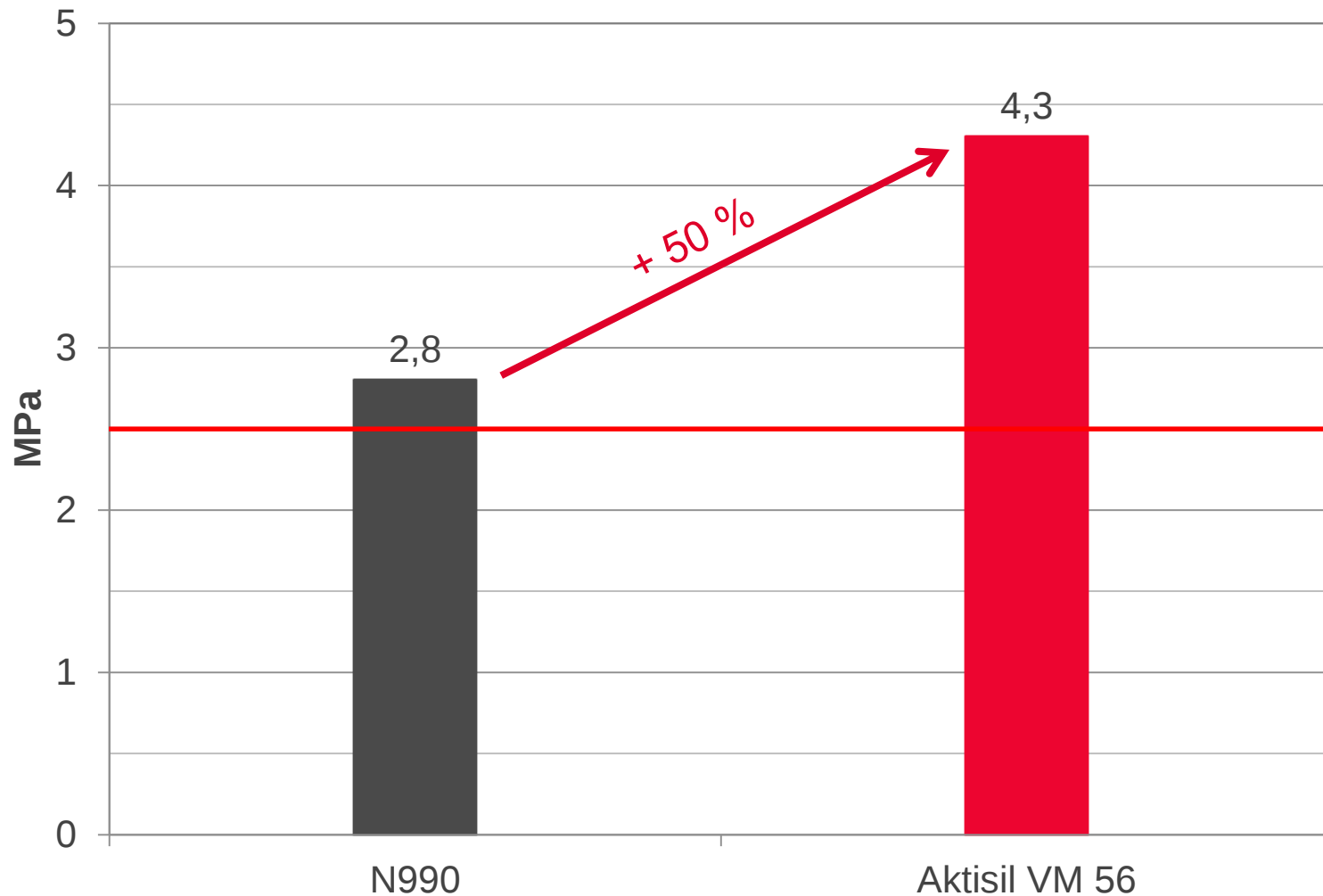


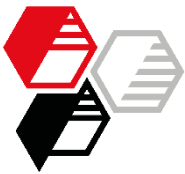


Modulus 100 %

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DIN 53 504, S2



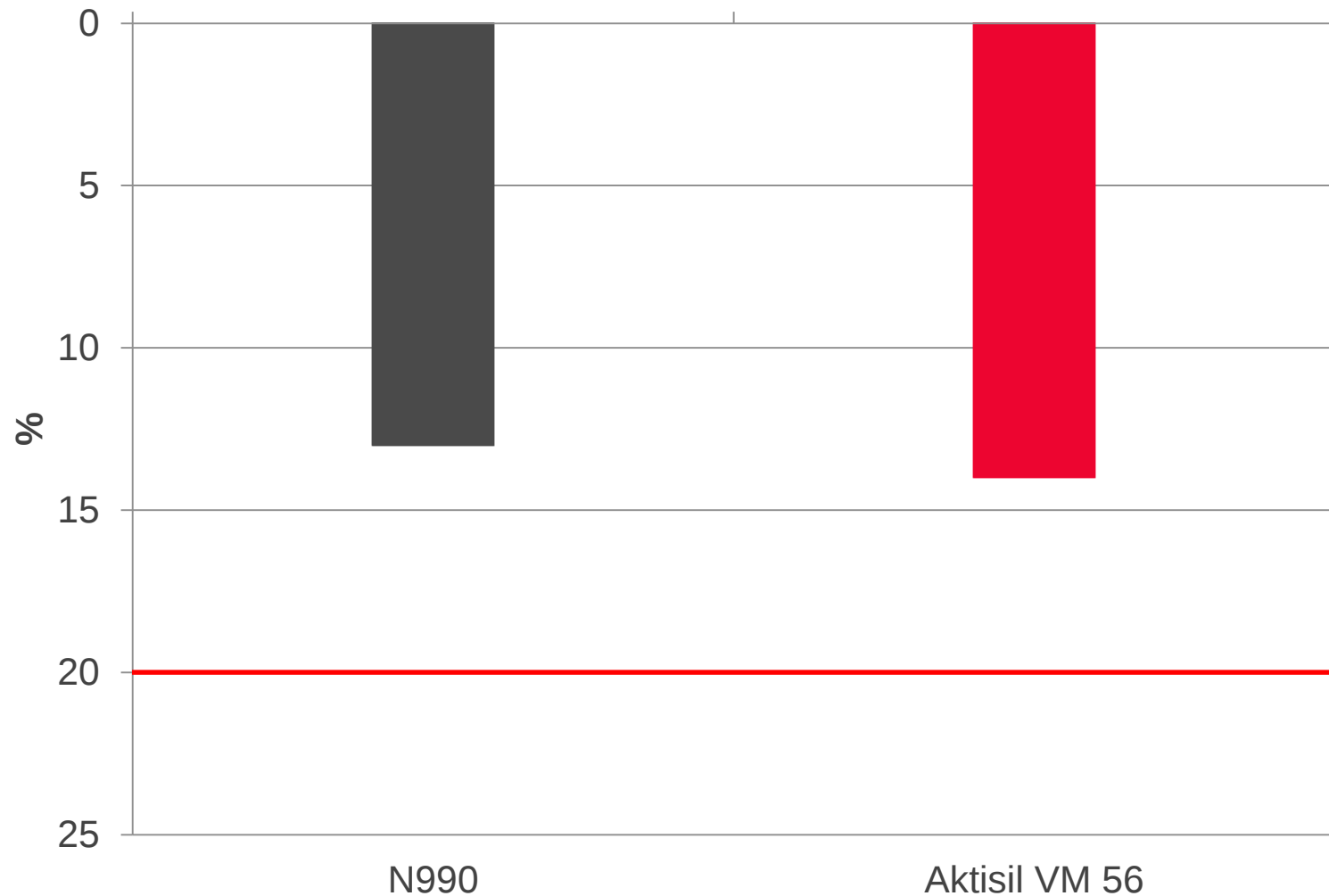


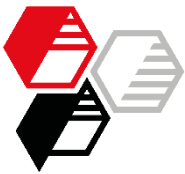
Compression Set

94 h / 23 °C

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P-VW 3307, 50 % deformation, 5 sec. relaxation



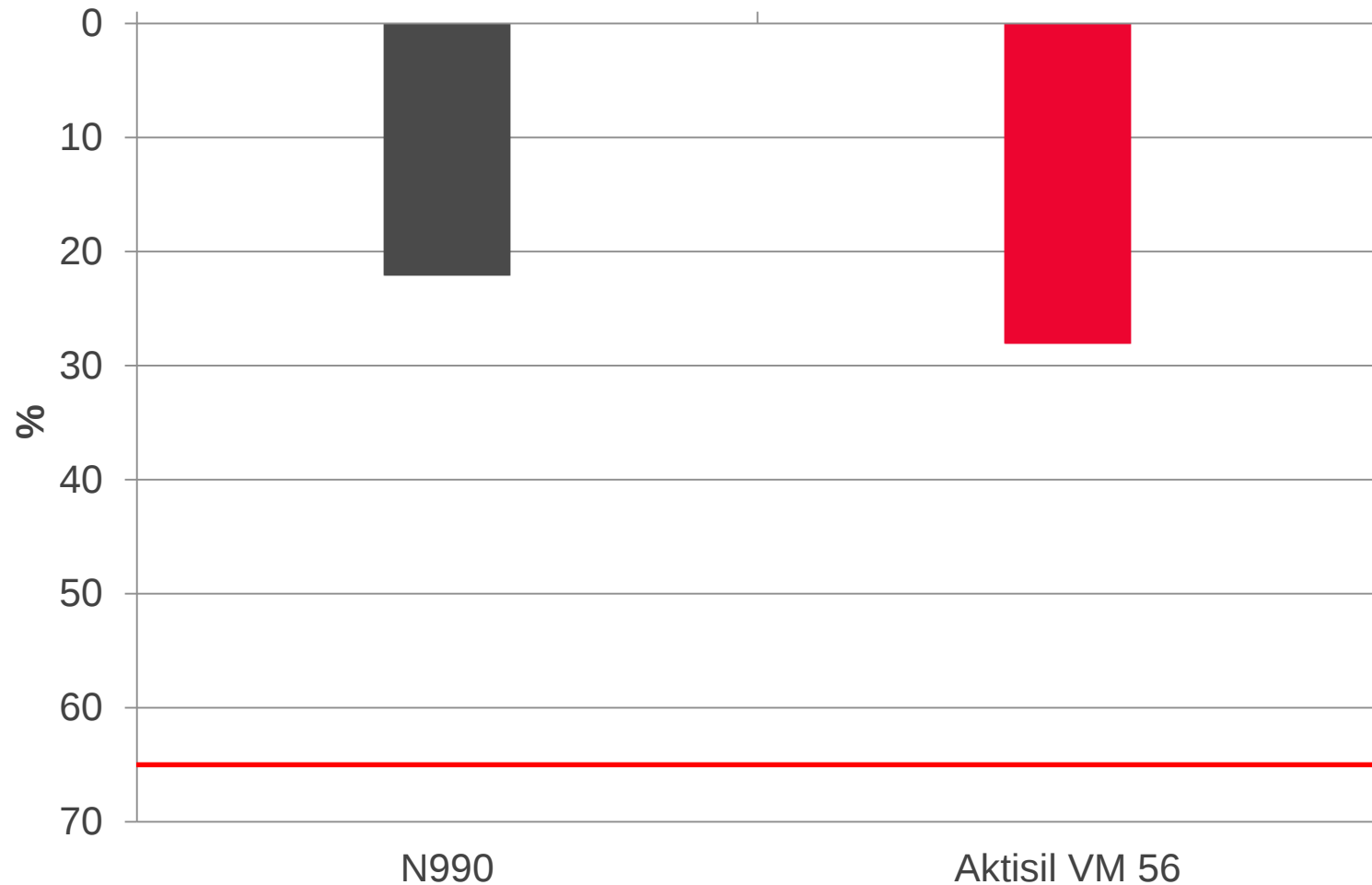


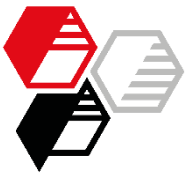
Compression Set

22 h / 120 °C

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P-VW 3307, 50 % deformation, 3 h cool down, 5 sec. relaxation



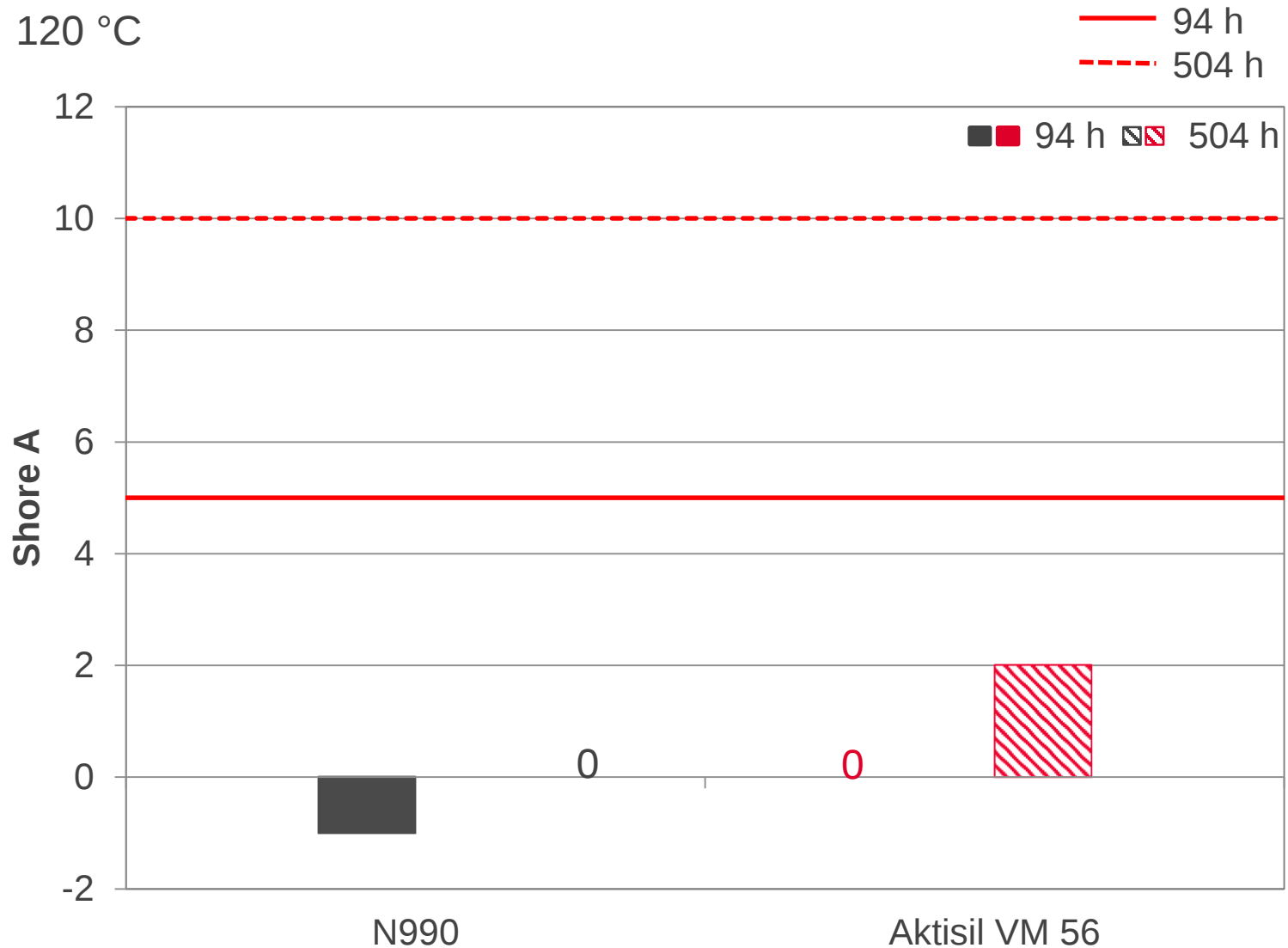


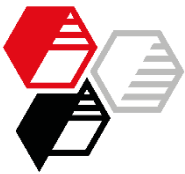
Storage in Hot Air

Change of Hardness

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120 °C

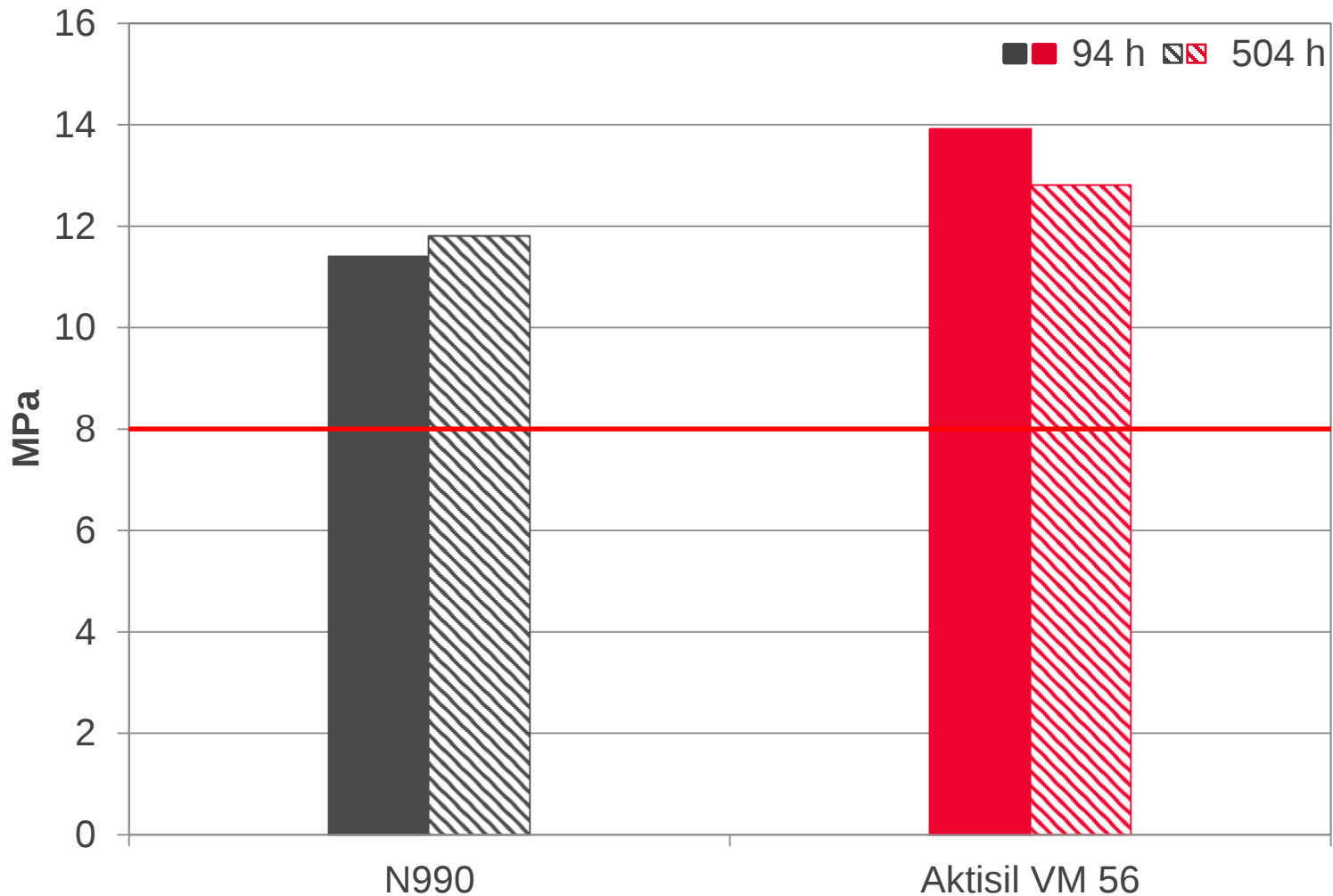


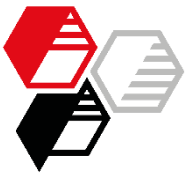


Storage in Hot Air Tensile Strength

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120 °C

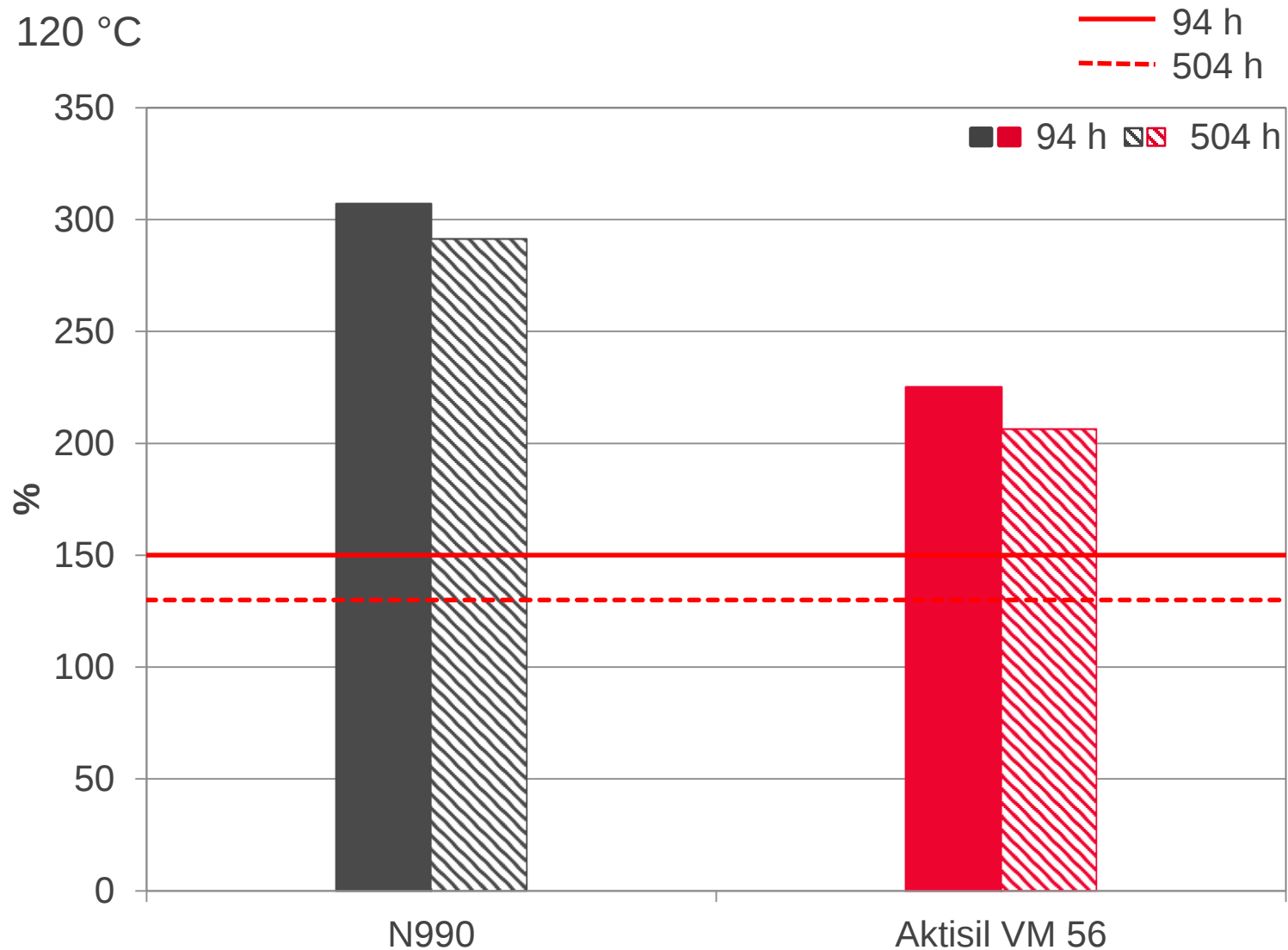


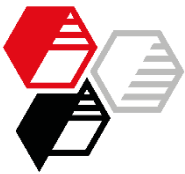


Storage in Hot Air Elongation at Break

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120 °C



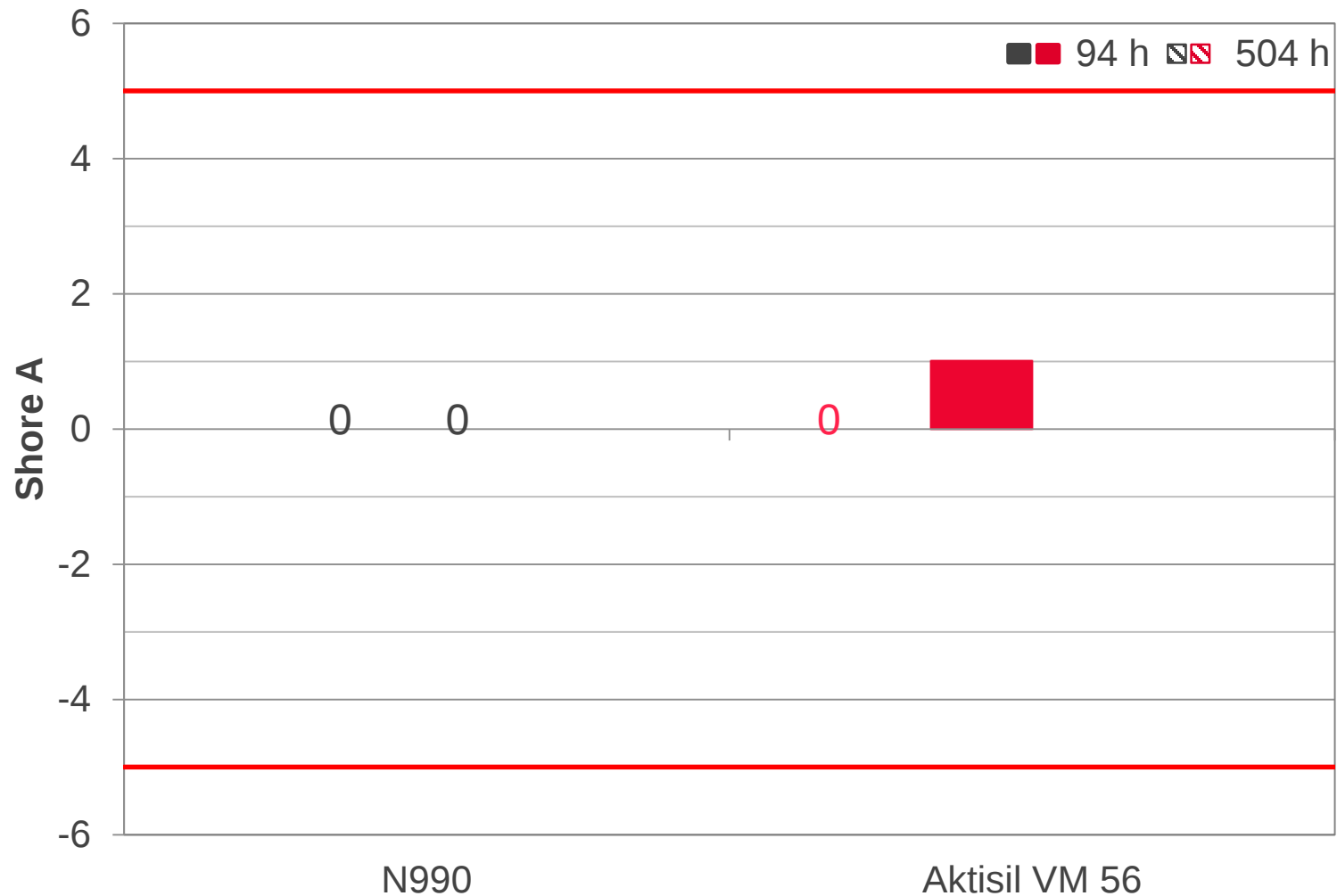


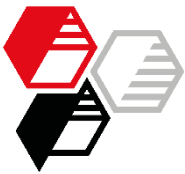
Storage in Urea Solution

Change of Hardness

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80 °C

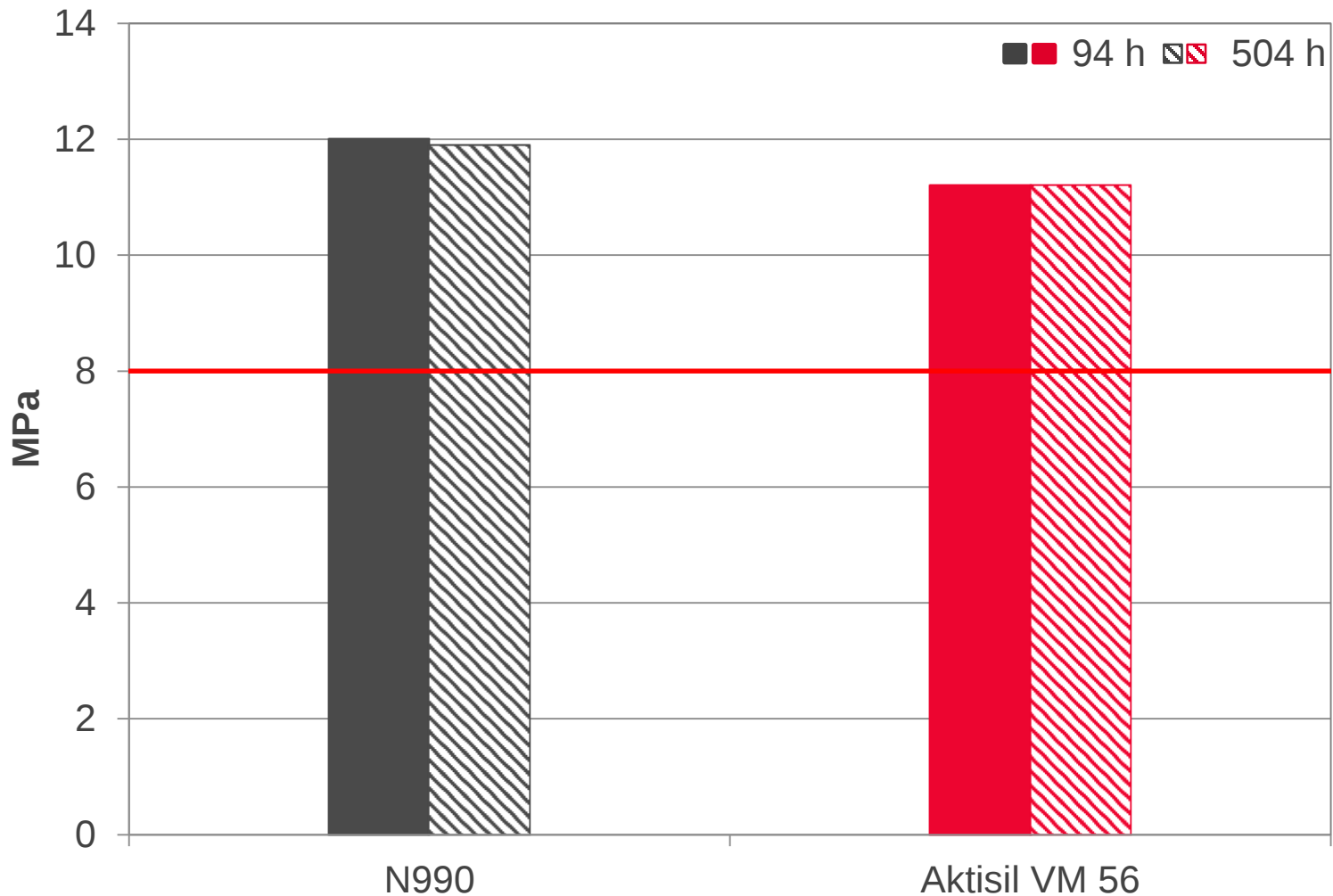


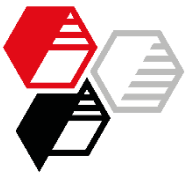


Storage in Urea Solution Tensile Strength

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80 °C

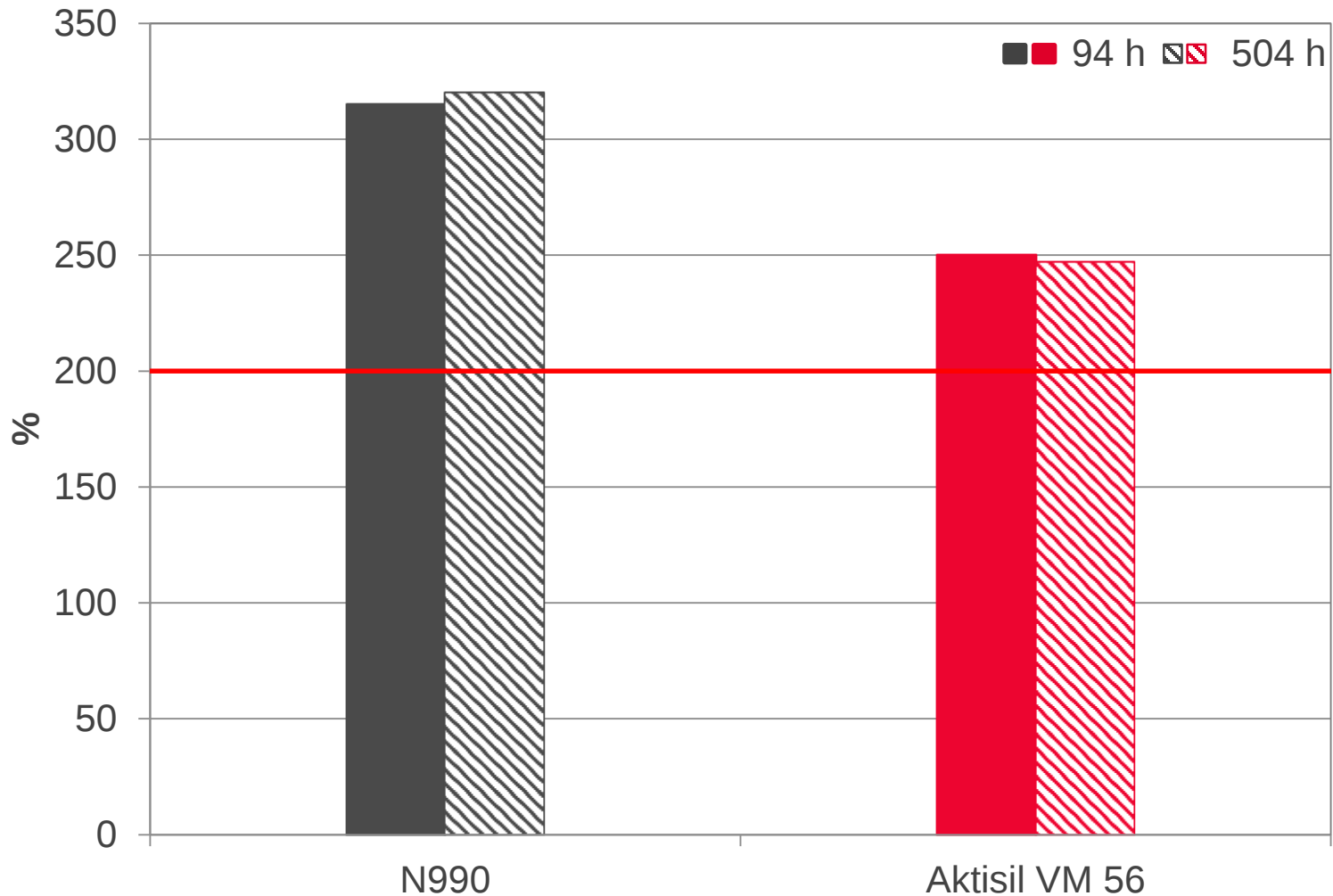


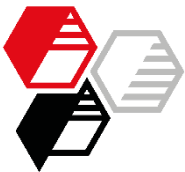


Storage in Urea Solution Elongation at Break

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80 °C





Storage in Urea Solution

Change of Weight

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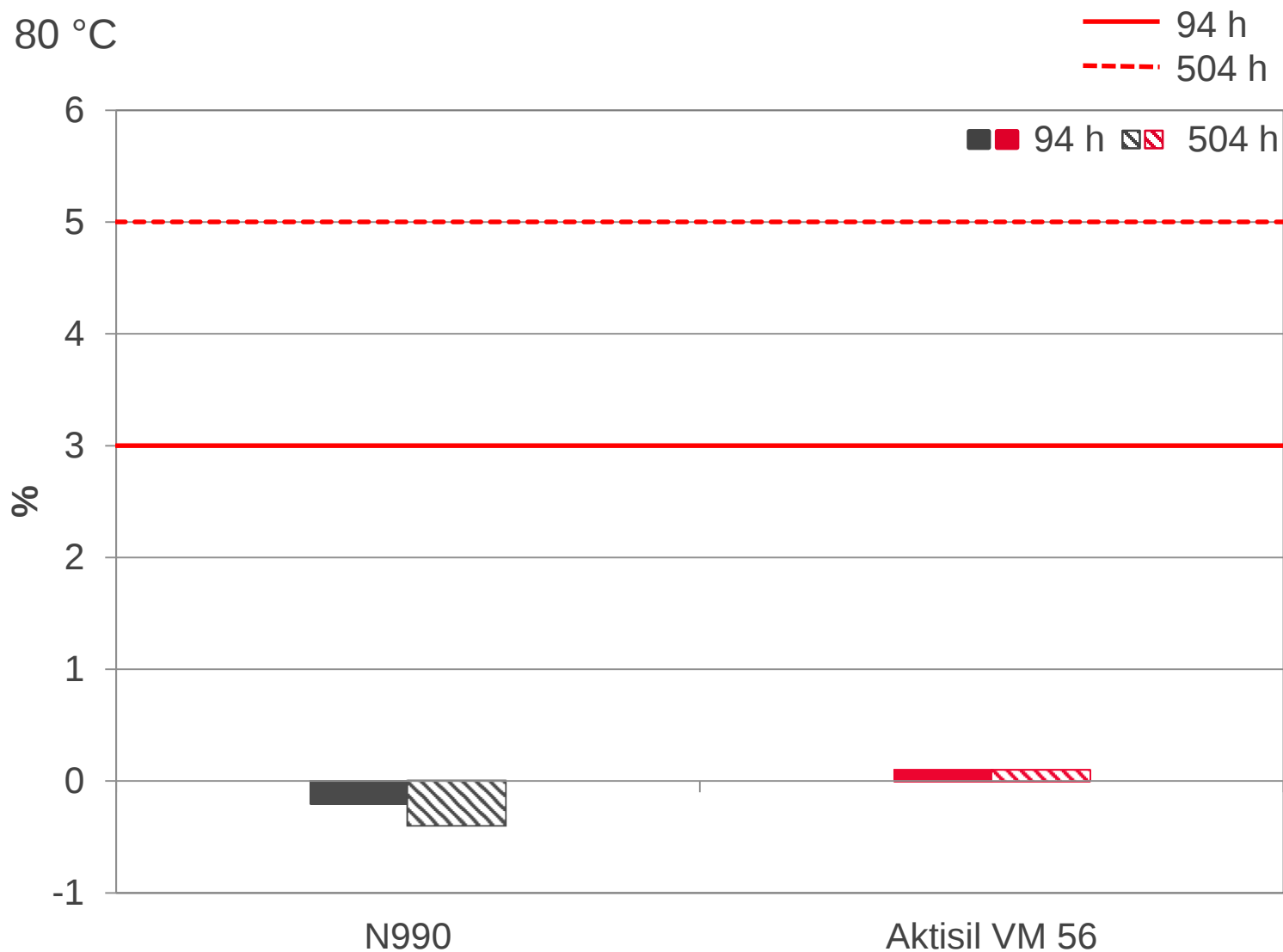
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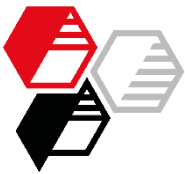
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80 °C





Blooming

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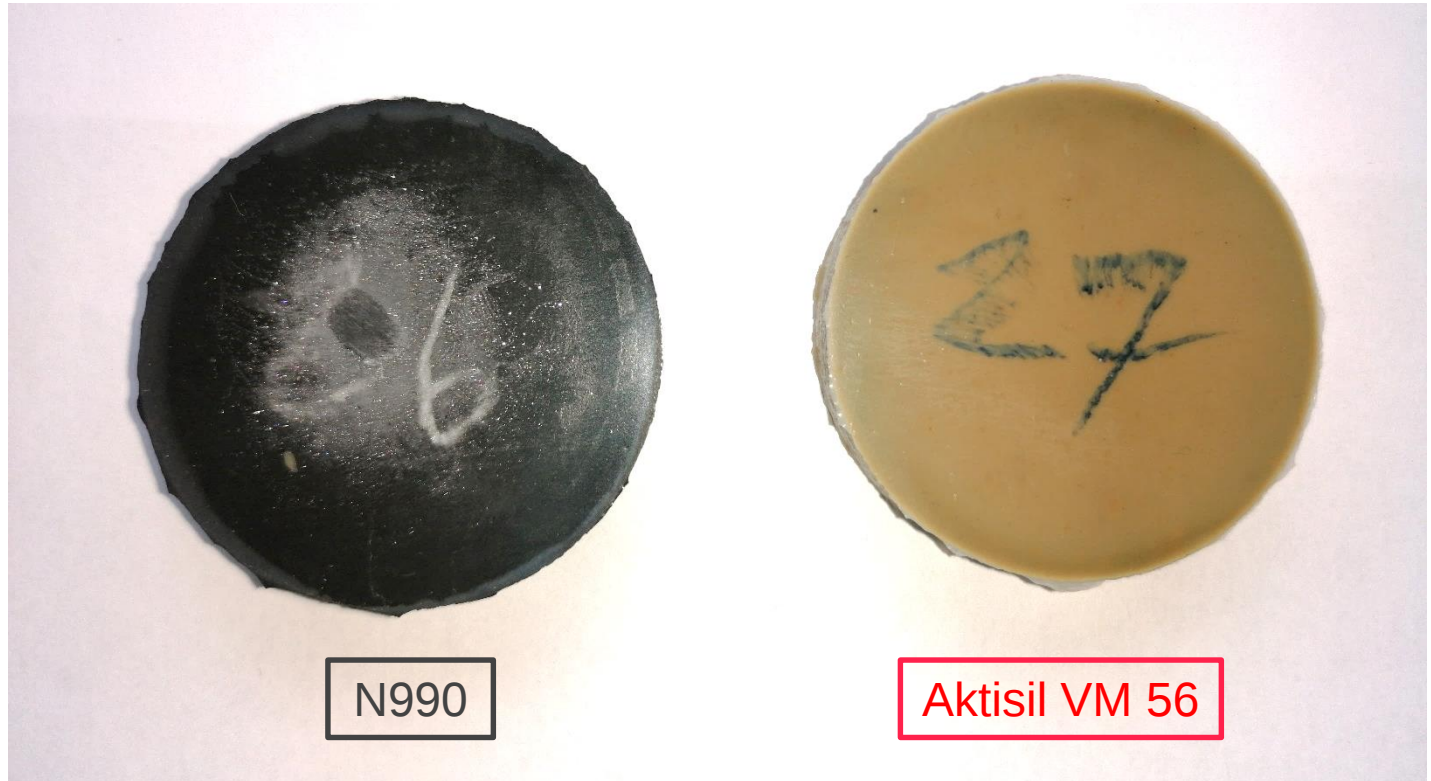
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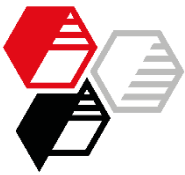
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- Blooming occurs only when using N990 one day after vulcanization



Hose Extrusion

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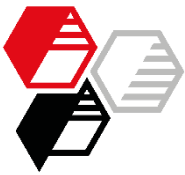
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Extruder		Schwabenthan Polytest 30 R
Screw diameter	[mm]	30
Working length	[mm]	450
Temperature set point head / zone 1 / zone 2	[°C]	110 / 70 / 70
Profile		see below
Feed strips		Cold untreated
Haul-off speed		5 m/min.

Tube Extrusion Die





Tube Extrusion Die

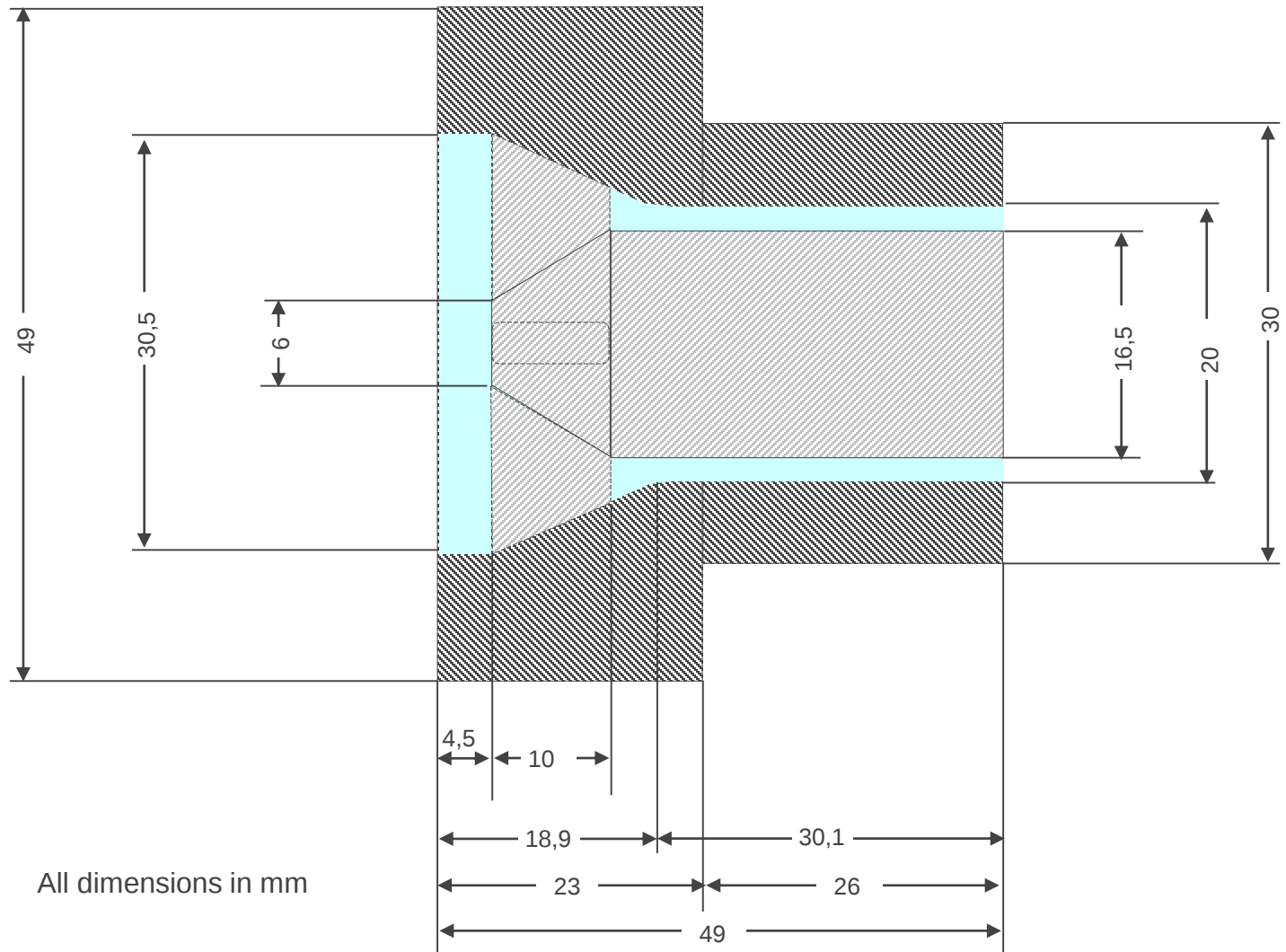
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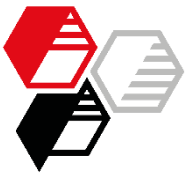
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Hose Extrusion

D_a : 20 mm / D_i : 16,5 mm

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Haul-off speed: 5 m/min.

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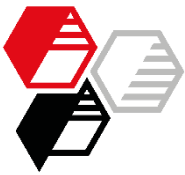
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Surface Quality



Collapse Resistance

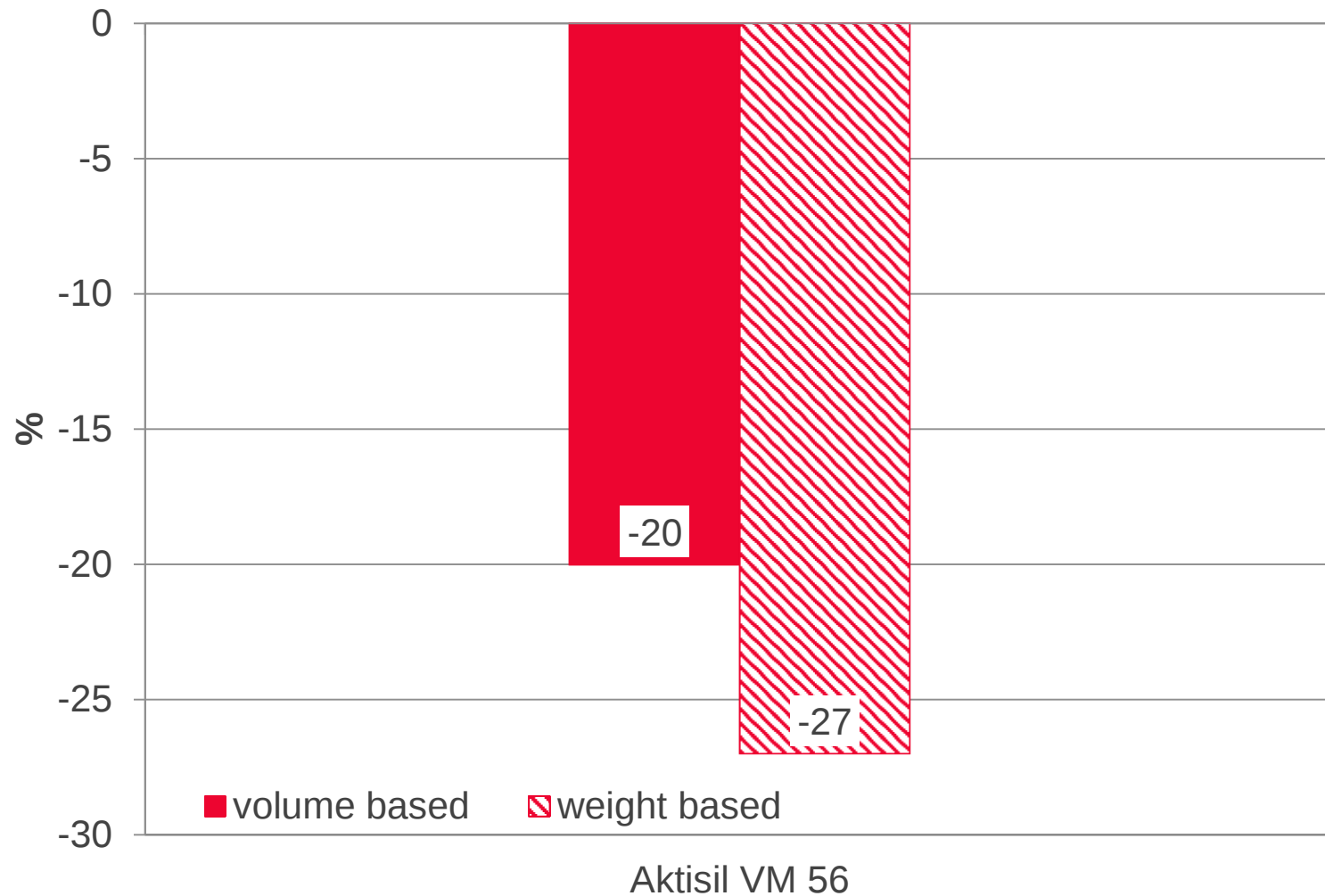


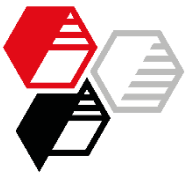


Cost Aspects

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Germany, 2019





Conclusion

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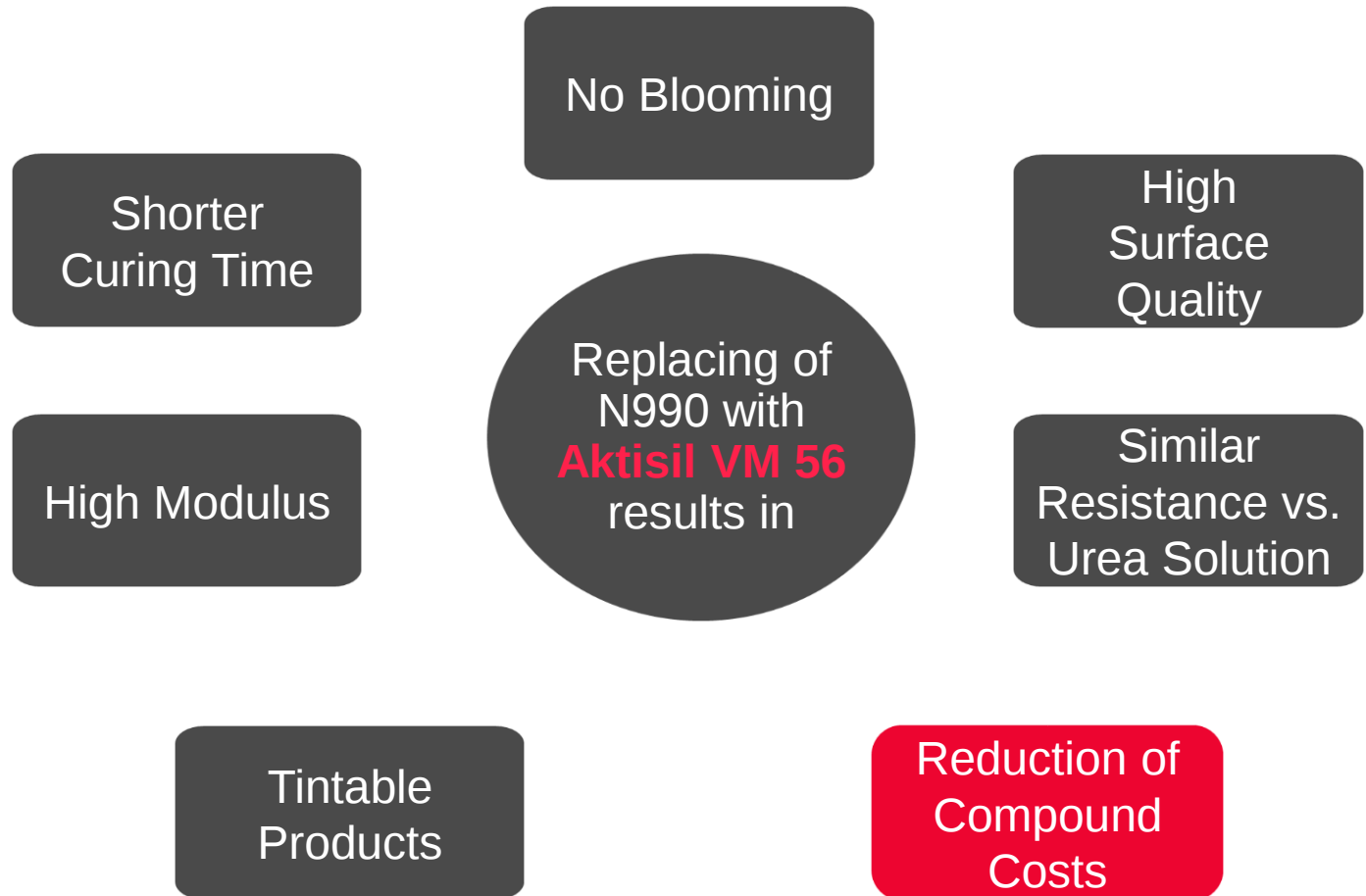
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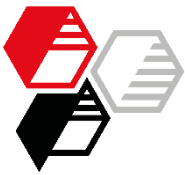
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Requirements of **VW TL 52686** are met



We supply material for good ideas!

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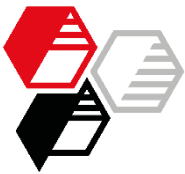


Table of Results

		N990	Aktisil VM 56
Rheology			
Mooney viscosity, ML 1+4, 120 °C	MU	46	53
Mooney scorch time, ML +5, 120 °C	min	77	56
Rotorless curemeter M _{min} 180 °C	Nm	0.09	0.09
Rotorless curemeter M _{max} 180 °C	Nm	1.03	0.96
Rotorless curemeter M _{max-min} 180 °C	Nm	0.95	0.87
Rotorless curemeter V _{max} 180 °C	Nm / min	0.40	0.54
Rotorless curemeter t ₅ 180 °C	min	0.46	0.39
Rotorless curemeter t ₁₀ 180 °C	min	0.59	0.47
Rotorless curemeter t ₉₀ 180 °C	min	5.58	4.66
Rotorless curemeter tan delta 180°C		0.04	0.04

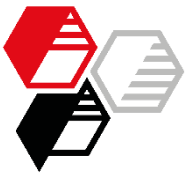


Table of Results

		N990	Aktisil VM 56
Mechanical properties			
Hardness	Sh. A	61	65
Tensile Strength	MPa	10.8	11.7
Modulus 50 %	MPa	1.4	2.0
Modulus 100 %	MPa	2.8	4.3
Elongation at break	%	305	248
Tear resistance	N / mm	3.1	3.1
Rebound elasticity	%	59	59
Compression set, 94 h / 23 °C, VW	%	13	14
Compression set, 22 h / 120 °C, VW	%	22	28
Compression set, 24 h / 23 °C, 25 % Def.	%	5	6
Compression set, 24 h / 120 °C, 25 % Def.	%	7	10

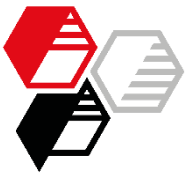


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		N990	Aktisil VM 56	N990	Aktisil VM 56
Storage in hot air; 120 °C; Measuring after 30 minutes		94 h		504 h	
Hardness	Sh. A	60	65	61	67
Tensile Strength	MPa	11.4	13.9	11.8	12.8
Modulus 50 %	MPa	1.5	2.3	1.6	2.3
Modulus 100 %	MPa	2.9	5.1	3.1	5.2
Elongation at break	%	307	225	291	206
Tear resistance	N / mm	3.2	2.7	3.2	2.6
Δ Hardness	Sh. A	-1	0	0	2
Δ Tensile strength	%	5.1	18.8	8.9	9.1
Δ Modulus 50%	%	4.0	12.8	10.6	15.4
Δ Modulus 100%	%	3.8	20.7	12.3	23.1
Δ Elongation at break	% rel.	0.6	-9.4	-4.6	-17.2
Δ Tear resistance	%	1.6	-11.8	2.9	-16.3

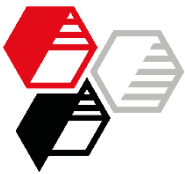


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		N990	Aktisil VM 56	N990	Aktisil VM 56
Storage in urea solution 80 °C; cool down 90 minutes		94 h		504 h	
Hardness	Sh. A	61	66	61	65
Tensile strength	MPa	12.0	11.2	11.9	11.2
Modulus 50 %	MPa	1.5	2.0	1.5	2.0
Modulus 100 %	MPa	2.9	4.1	2.9	4.1
Elongation at break	%	315	250	320	247
Δ Hardness	Sh. A	0	1	0	0
Δ Tensile Strength	%	11.0	-4.7	9.7	-4.7
Δ Modulus 50%	%	5.1	0.2	5.3	1.8
Δ Modulus 100%	%	6.3	-3.5	6.3	-2.7
Δ Elongation at break	% rel.	3.2	0.6	5	-0.4
Δ Weight	%	-0.2	0.1	-0.4	0.1
Δ Volume	%	-0.3	0.1	-0.4	0.4